ANALYSIS OF SELECTED ENVIRONMENTAL TOBACCO SMOKE COMPONENTS IN INDOOR AIR BY THERMAL DESORPTION-GC-MS

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SUMMARY

In recent years, environmental tobacco smoke (ETS) has been the subject of increased research activities. In order to measure the concentration of selected ETS components in indoor air, we developed a sensitive analytical method which utilizes a portable vacuum pump in conjunction with a Tenax trap, a thermal desorption injection device and gas chromatography-mass selective detection (MSD). The latter was operated in the selective ion monitoring mode (SIM) to optimize selectivity.

Compounds analyzed include benzene and alkylbenzenes, pyridine, picolines, 3-vinylpyridine, limonene and nicotine. We sampled several smoking and nonsmoking environments (restaurants, bars, cars, homes, offices etc.).

Nicotine was found at levels ranging from 0 to 117 µg per m^3, while the concentration of the other volatile organics ranged from <0.1 to 167 µg/m^3. Limonene was found at very high levels in a restaurant and a new car (254-320 µg/m^3), possibly due to the use of some lemon-scented cleaning agents.

The system is very sensitive, allowing the analysis of only 1.5 l air (detection limit <0.3 ng of nicotine per sample). In addition to nicotine, 3-vinylpyridine was found to be a good marker for ETS exposure.

INTRODUCTION

Environmental tobacco smoke (ETS) has been recognized as an important component of indoor air pollution. Recent epidemiological studies have incriminated ETS as a risk factor for lung cancer in nonsmokers (1-3). As a result, several studies have been undertaken to analyze ETS (4-7). Since nicotine is the habituat-

ing agent in tobacco and tobacco smoke (8), several studies have concentrated on the analysis of only nicotine in ETS (9-12). Among the most common analytical methods used are trapping of nicotine on Cambridge filters treated with potassium bisulfate (4,10,13), trapping of nicotine on XAD resins (5,9,13) or trapping of whole ETS on Tenax tubes with subsequent analysis by thermal desorption followed by gas chromtography (GC; 11) or mass spectrometry (MS; 12). In a recent study, we have analyzed several volatile ETS components such as 1,3-butadiene and benzene using GC-MSD (14). It was the goal of this study to analyze in detail selected volatile and semivolatile ETS components using thermal desorption-GC-MSD.

MATERIALS AND METHODS

Apparatus. The GC-MSD system consisted of a Hewlett Packard Model 5890 gas chromatograph interfaced with a Model 5970 MSD, an HP 59970 GC-MS workstation software run on an HP 9000 series 300 computer. The gas chromatograph was equipped with a Chrompack thermal desorption cold trap injector (# 16230) and a cryogenic control for liquid CO_2. The sampling of ETS was carried out using a portable vacuum pump (DuPont Alpha 1).

Analysis of ETS. Air samples were collected on glass cartridges packed with 200 mg Tenax TA (20-35 mesh) preconditioned at 250°C overnight. A total of 1.5 l air per sample was collected at a flow rate of 50 ml/min (under these conditions, no breakthrough was observed).

The sample cartridges were desorbed at 250°C for 10 min. using a cryotrap at -73°C which subsequently was heated to 250°C at 15°/sec. The gas chromatographic column was a 30 m x 0.25 mm (i.d.) DB-5 (1 micron film thickness) fused silica. The GC oven was kept at -20°C for 2 min. and then ramped to 250°C at 20°C/min. The injection port temperature was kept at 250°C and the carrier gas had a flow rate of 1 ml He/min. The MSD was operated in the SIM mode at four different time "windows". Under these conditions, the entire chromatogram eluted in 17 minutes (Figure 1).

RESULTS AND DISCUSSION

Air samples were collected from several smoking and nonsmoking environments, including restaurants, bars, cars, offices, homes, laboratories, and an indoor garage. Table 1 shows the levels of benzene, alkylbenzenes, pyridine, picolines, 3-vinylpyridine, limonene, and nicotine.

Among several different adsorbents (Carbopack 8, Carboxen 564, carbosieve III, molecular sieve 5A), Tenax TA was found to be the most effective one; however, it is not suitable for trapping smaller molecules such as 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, furan, isoprene, acrylonitrile and acetonitrile. Aging studies showed that ETS samples collected on Tenax TA were stable for a week when kept refrigerated. As can be seen in Table 1, benzene and some alkylbenzenes are ubiquitous, ranging from 3 to 167 $\mu g/m^3$; the levels of pyridine and picolines observed in ETS are significantly lower in comparison (up to 16 $\mu g/m^3$). It should be pointed out that benzenes and pyridines are by no means specific to tobacco smoke since they are produced by other sources, such as automobile exhaust.

Limonene was detected at considerable levels in a restaurant (both in smoking and nonsmoking sections) and a new car which we attribute to the use of lemon-scented cleaning agents, although limonene is also present in cigarette smoke. Except for a laboratory, limonene was found present in all other samples, ranging from 2-94 $\mu g/m^3$. The laboratory air sample had the lowest overall levels of the compounds analyzed in this study, most likely because of the frequent air exchanges.

Nicotine in smoking environments was present from 14-117 $\mu g/m^3$. This compares well with other studies; Thompson *et al.* found up to 37 μg nicotine/m^3 in restaurants (11) while Eatough measured nicotine in discos and found up to 119 $\mu g/m^3$ (7). In a nonsmoking area of a restaurant we found up to 6 μg nicotine/m^3, possibly due to contamination effects from the adjacent smoking section. In an office officially labeled nonsmoking, we detected 3.7 μg of nicotine/m^3; we assume that this is due to some limited smoking activity.

3-Vinylpyridine was present in all sites sampled amounting up to 35 $\mu g/m^3$. Since 3-vinylpyridine is a combustion product of nicotine, it is a useful marker for ETS. In a recent study where nonsmokers were exposed to ETS from high yield and low yield cigarettes, it was found that 3-vinylpyridine correlates very well with urinary cotinine (r=0.98; 15). We did not expect a significant difference in 3-vinylpyridine levels between high yield and low yield cigarettes because the sidestream smoke yields as such are not very different among different cigarettes (16).

The analaytical method reported here using the cryogenic GC-MSD-SIM is very specific and highly sensitive (detection limit $<0.2\ \mu g/m^3$ or <0.3 ng/sample) and should also be suitable for the determination of trace components in other complex matrices.

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TABLE 1

SELECTED COMPOUNDS IN ENVIRONMENTAL TOBACCO SMOKE ($\mu g/m^3$)

Compound	Restaurant		Bar	Car		Office	Home		Lab	Garage
	NS	S	S	NS	S	NS	NS	S	NS	NS
Benzene	36	69	107	40	31	15	9	47	5	29
Pyridine	4	n.d.	16	n.d.	0.6	0.4	n.d.	3	0.2	0.4
Toluene	62	26	167	7	42	30	68	134	15	121
2-Picoline	1	5	7	1	n.d.	0.3	n.d.	n.d.	n.d.	0.1
3 + 4-Picoline	2	8	13	1	1	0.6	1	1.5	n.d.	0.4
Ethylbenzene	10	21	44	72	9	4	36	13	3	40
m + p-Xylene	19	43	131	o.l.	36	12	119	48	8	134
o-Xylene	11	22	52	104	12	5	45	19	3	57
3-Vinylpyridine	2	18	35	17	2.5	1.4	10	10	0.6	5.3
1,2,4-Trimethylbenzene	17	61	55	38	13	6	56	21	6	72
Limonene	254	320	94	292	17	10	5	27	n.d.	2
Nicotine	6	103	117	2	14	3.7	n.d.	17	n.d.	n.d.

NS = nonsmoking; S = smoking; n.d. = not detected (<0.2 $\mu g/m^3$); o.l. = overload.

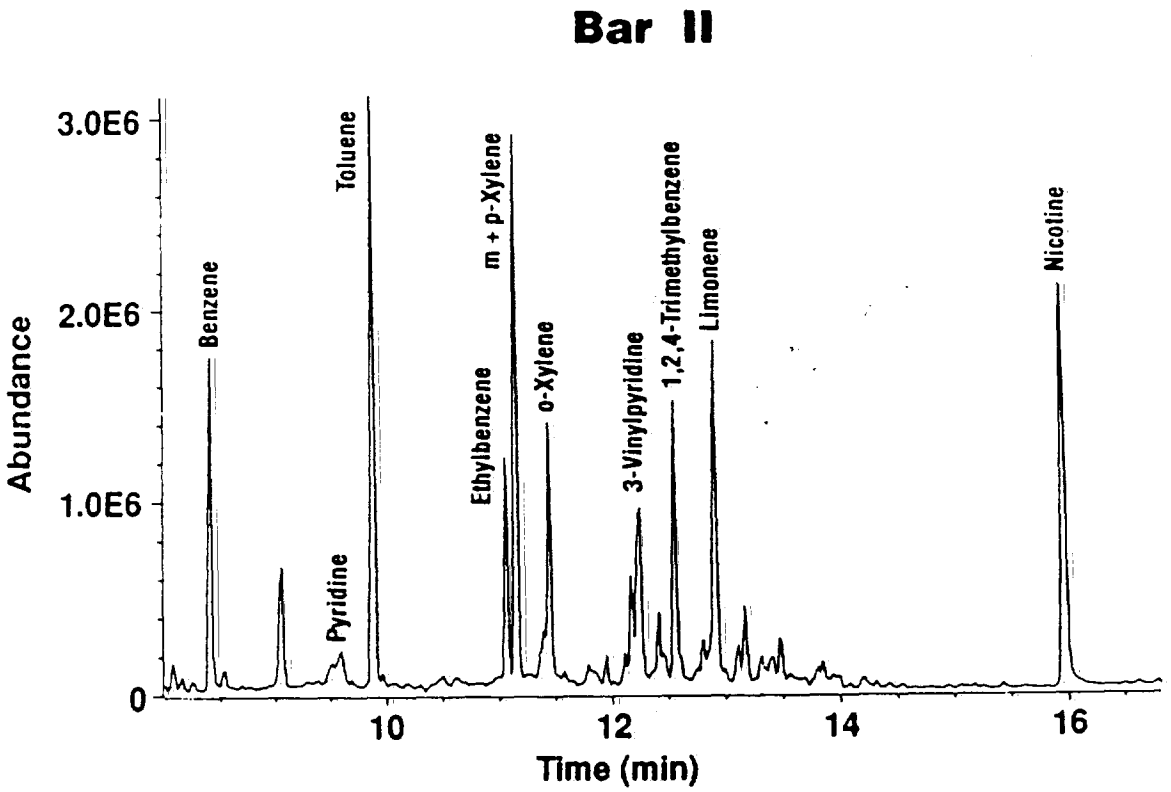

Figure 1. Gas chromatogram of selected components in ETS.